

Materials Testing and Certification Plan for the KamLAND 4π Off-Axis Calibration System

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I. Introduction

According to the general guidelines outlined by the calibration committee and the calibration coordinator [1,2] the 4π system needs to be certified for compatibility and cleanliness before it is installed, commissioned, and used as a calibration source deployment system. The relevant documents describing the existing certification requirements for the KamLAND 4π system as well as other KamLAND calibration systems and sources are attached in the Appendix of this note.

The quantitative question of what constitutes acceptable background levels and sufficiently clean parts is not addressed in this note and will require further discussion between the calibration committee and the collaboration.

II. KamLAND 4π System Hardware

The KamLAND 4π system consists of an extension to the existing glovebox including a new deployment system and the calibration pole that will be immersed into the inner liquid scintillator of the detector. The most stringent cleanliness criteria apply to the parts that will come in contact with the liquid scintillator in the inner volume of the detector. These parts include (excluding the calibration source itself):

Item

1. control cable
2. titanium calibration pole segments
3. titanium source mount
4. stainless steel calibration source protection cage
5. titanium cable attachment pole segments
6. encapsulated pressure sensor and LED instrumentation units
7. stainless steel pivot block

The materials testing and certification plan outlined in this note is designed to address the issue of materials compatibility and cleanliness for these items. All hardware in the glovebox and its extension is designed and built according to the general guidelines outlined in the Appendix of this document.

III. Materials Compatibility and Cleanliness Test Program

All materials for items 1-8 were chosen to be compatible with the liquid scintillator. It remains to be shown that these items and the materials used to build them

- A. do not affect the optical property of the liquid scintillator
- B. do not leach any radioactive contaminants into the liquid scintillator
- C. do not emanate an unacceptable amount of Radon into the liquid scintillators

Issues A-C will be addressed through

- a. spectrometer measurements of liquid scintillator soak samples of the materials
- b. low-background counting of weak nitric acid soak samples of parts 1-7
- c. low-background counting of liquid scintillator soak samples of parts 1-7

In addition some of the parts from items 1-8 will be counted dry to provide an early verification and cross-check of the cleanliness of these parts. Before any of the 4π parts are counted they will undergo the UHV cleaning procedure described in Ref. [4]. This procedure will also be used for the final cleaning of the 4π parts before they are shipped to KamLAND.

We propose to pursue two parallel background counting programs utilizing the facilities at LBNL and on site in Mozumi. This will allow us to maximize the amount of information we can collect on the background and cleanliness of the 4π parts.

At LBNL we will (in the following order)

1. Perform the dry count of selected UHV-cleaned parts for an early evaluation.
2. Build a container for a weak nitric acid soak of all parts 1-7 and perform subsequent counting of a liquid soak sample to check for leaching effects. The parts will be soaked for about 1 week. This test samples all finished parts that will be immersed into the inner detector. After this test the parts will be UHV cleaned according to the procedures in [4].
3. Build a container for a liquid scintillator soak of all parts 1-7 and perform subsequent counting of a liquid soak sample to check for effects of Radon emanation. The parts will be soaked for about 1 week. This test samples all finished parts that will be immersed into the inner detector. After this test the parts will be UHV cleaned according to the procedures in [4].

At Mozumi the following tests can be performed (depending on the availability of personnel):

1. Spectrometer tests of long-term liquid soak samples that have been soaking on site to check for materials compatibility with liquid scintillator.
2. Low-background counting of liquid scintillator soak samples.

(Experimental details of the proposed tests in Mozumi will require further discussion. For example, we will need to discuss if the current materials samples are acceptable or should undergo UHV cleaning before they are being soaked in liquid scintillator.)

References

- [1] J. Busenitz, H. Steiner
- [2] E. Yakoushev
- [3] A. Piepke, *private communication*, April 2004
- [4] LBNL UHV cleaning procedure, January 2004
http://kmheeger.lbl.gov/kamland/4pi/materials/UHV_CLEANING_PROCEDURES.pdf

Appendix A – Kamland 4 π system - Materials Certification Protocol

Kamland 4 π system - Materials Certification Protocol

(HS Draft of 1/31/03 as modified by JB&HS on 2/6/03)

Policy

In order to avoid compromising the performance or operation of the KamLAND detector the following policy will govern all deployment-related tasks:

- No materials shall be submerged in the scintillator or put into the glove box without prior approval by the designated on-site representatives of the KamLAND collaboration. Until further notice these persons are G. Guillian and M. Koga.
- All materials used in the detector and in the glove box must be properly certified. There will be two classes of certification: A and B. Class A pertains to all materials to be submerged in the scintillator. Class B pertains to materials that will normally remain in the glove box. These certifications will be described in the next section of this document.
- A responsible person must be associated with every item to be deployed, and that person must enter a record of the certification procedure into the KamLAND e-log. Until further notice M. Galloway will be the 4 π -system certification coordinator, and will be responsible for all 4 π -system certifications.
- All certified materials must be re-certified if they are exposed to an unclean environment.
- Only certified operators are authorized to put or manipulate materials in the detector and the glove box.
- Only approved deployment procedures are to be used.
- The fire marshal must approve all procedures and operations involving potential fire or explosion hazards.

Certification

The purpose of the certification procedure is to insure that insertion of materials does not introduce lasting radioactive or chemical contaminants into the experiment, nor to endanger the mechanical integrity of the detector. The certification requirements are intended to be stricter for materials in direct contact with the scintillator (class A) than those exposed only to dilute vapors (class B). No hard and fast rule will cover every case. Common sense and safety consciousness should always be prime considerations.

Class A Certification

- Only materials on the pre-approved materials list should be submerged in the scintillator.
- Class A certification must include (but is not limited to) the following procedures:
 - (1) Approved cleaning. Whenever possible this should include a weak acid soak (at least one day), unless there is a danger that the material would be damaged by the acid.
 - (2) Scintillator soak for period of time comparable to or greater than time the material is expected to be submerged in the detector. Care must be taken to provide controls for counting and optical measurements.
 - (3) No detectable increase in post-soak scintillator/weak acid radioactivity
 - (4) No detectable changes in post-soak scintillator optical properties
 - (5) No significant increase in detectable chemical contaminants This step may not be necessary if material is already certified to be compatible with scintillator.
 - (6) All pressure sensitive items must pass a standard pressure test of at least 2 atmospheres before they are deployed. All seals must be free of leaks.
 - (7) All certified items shall be carefully packed, preferably hermetically, and assembled in a clean environment
 - (8) A full record of the certification procedure shall be entered into the e-log. This record shall include a statement by the responsible person that in his/her best judgement the certified item is safe for insertion.
- Every item to be inserted into the liquid must be receive class A certification except for identical copies of certain mechanical components (e.g., mast and boom sections, couplers, other hardware, etc). For these pieces a preparation procedure will be defined based on assay of samples (filings, swipes, etc.). All objects to be submerged must have undergone an approved cleaning procedure and have been checked for gross radioactivity prior to deployment.

- All individual parts should be marked permanently with an appropriate serial number (or other identifying label). That label should be used to identify items in the certification document.

Class B Certification

- Whenever possible only pre-approved materials should be used inside the glove box. Exceptions to this policy will be considered as needed, but only if the associated risk is deemed to be acceptable by the collaboration. Except in emergency situations a lead time of one week is required for all such requests. The heads of the calibration group, in close consultation with other members of the collaboration and especially relevant experts, will make the required decision(s).
- Except for radioactive calibration sources all materials to be put in the glove box (and associated environment) must be certified to be clean and free of gross radioactivity.
- In general no soak tests or low level radioactivity measurements need to be made for glovebox items that are not submerged.
- Glovebox items must be certified not to introduce light or gas leaks, nor to introduce a potential fire hazard.
- Class B certification of all glovebox items shall be recorded in the e-log.

The attached spread sheet, prepared by M. Galloway, spells out the various certification tasks in more detail.

Appendix B – General KamLAND Source Certification Requirements

KamLAND Certification Requirements

The following information must be provided about all materials to be inserted into the detector and glove box. (For a radioactive source, this information must be supplied and approval granted before the source can be brought into the dome area.) The method of deployment should be clearly specified. For each item the test procedure should be described in sufficient detail that judgements can be made about its effectiveness. In all cases you are asked to provide the nature of the test, the names of those making the test, time and place of the test, the test procedure(s), any references, and the results of the tests. Please indicate if others are responsible for certain parts of this procedure. You should point out any potential problems of which you are aware. Approval to deploy will not be considered without a written statement from the requester that he/she certifies that to the best of his/her knowledge it is safe to do so. This statement should be submitted (e.g. e-mailed) to the entire collaboration at least one week prior to the requested deployment. No deployment is to be made without prior approval by the designated representatives of the calibration group, at present G. Guillian and M. Koga. They are authorized to deny or delay approval if in their opinion the procedures and certifications are not acceptable. They are encouraged to consult with other members of the collaboration (and elsewhere if necessary) to clarify any unresolved issues.

The written certification should contain:

- (1) A brief description of the source: What is it? What is its purpose? How will it be used?
- (2) What is the material composition and geometry? How was it fabricated? When?
- (3) What is known about radiopurity? Describe all tests that have been done.
- (4) What is known about compatibility with the scintillator? Describe all tests that have been done.
- (5) Mechanical integrity and stability? Pressure tests?
- (6) How will the source be deployed? Use of deployment systems other than the “standard” phase 0/1 systems must be described in detail. Describe what has been done to insure that the source will not fail in the detector

Comments:

Loose or untethered components inside the glove box should be avoided. It is important to remind users that there may be only restricted direct visual information available when the HVs to the PMTs are on, and the gate valves are open. A wide-angle CCD camera that can be used with IR light is foreseen for future installation inside the glove box. Another important requirement is that only persons who are "licensed" by Gene and/or Koga-san will be allowed to use the glove box, and then only for predefined operations.

Appendix C - Email by on the Preparation of New Radioactive Sources

Date: Fri, 21 Nov 2003 19:34:43 -0600 (CST)
From: "Evgueni A. Iakouchev" <yakushev@bama.ua.edu>
Subject: Procedure of preparation of new radioactive sources to deployment will be changed
Sender: owner-kamland@awa.tohoku.ac.jp
To: kamland@awa.tohoku.ac.jp
X-Uwash-Spam: Gauge=IIIIIII, Probability=8%, Report="
Original-recipient: rfc822;kmheeger@imape.lbl.gov

Dear collaborators,

As you know now we have low background counting facilities on the site.

From now we will use it for additional checking of surface contamination of ANY new radioactive sources arriving on the site. Only sources already completely certified and approved to be deployed into KamLAND will be subject for the checking. So, this check is part of preparation to deployment, not certification.

Minimal procedure will be as follows:

1. Source should be soaked for 24 h (min) in a liquid known as a good solvent for radioactive material(s) used for source preparation. We expect to have recommendation from source producer about what liquid to use. Liquid for soak should be compatible with material of encapsulation. If solubility of used radioactive materials is under questions then KamLAND Is should be used for soak. For example both new AmBe and composite sources which will come on the site soon will be soaked in 0.1M solution of nitric acid. (we know it as a good solvent for radioactive materials used and encapsulation (sst) is compatible with it)
2. Soak sample will be counted on low background HpGe detector for a reasonable time.(that is not certification, just checking!!!)
3. If results are negative source will be deployed into KamLAND after any additional test and preparation procedures need for deployment. If any indication of a surface contamination will be found any other works for preparation of such a source to deployment will be stopped immediately, source will be send outside of the KamLAND area for future investigations.

Please allow 1-2 week additional delay time for deployment of any new sources. We hope that source producers will be cooperated in that final step before deployment.

Responsibility for above procedure is on the person on the site currently in charge for KamLAND calibration with radioactive sources.

Regards
Evgueni